# 73rd MORSS CD Cover Page

712CD

For office use only 41205

**UNCLASSIFIED DISCLOSURE FORM CD Presentation**

**21-23 June 2005, at US Military Academy, West Point, NY**

**Please complete this form 712CD as your cover page to your electronic briefing submission to the MORSS CD. Do not fax to the MORS office.**

**Author Request** (To be completed by applicant) - The following author(s) request authority to disclose the following presentation in the MORSS Final Report, for inclusion on the MORSS CD and/or posting on the MORS web site.


Name of Principal Author and all other author(s): **Gail-Tirrell Vaucher, Ronald Cionco, Manuel Bustillos, Sean D'Arcy, Robert Dumais, SFC Robert Brice.**

Principal Author's Organization and address:

**U.S. Army Research Laboratory**
**White Sands Missile Range, NM 88002**

**Phone: 505-678-3237**
**Fax: 505-678-3385**
**Email: gvaucher@arl.army.mil**


Original title on 712 A/B: **Urban Warfare: Detailing Single Building Airflow, Turbulence and Stability Variation Characteristics.**

Revised title:_____None_____

Presented in (input and Bold one): (WG-10, CG___, Special Session ___, Poster, Demo, or Tutorial):

This presentation is believed to be:
UNCLASSIFIED AND APPROVED FOR PUBLIC RELEASE

# Report Documentation Page

*Form Approved*
*OMB No. 0704-0188*

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

| 1. REPORT DATE | 2. REPORT TYPE | 3. DATES COVERED |
|---|---|---|
| **23 JUN 2005** | **N/A** | **-** |

| 4. TITLE AND SUBTITLE | 5a. CONTRACT NUMBER |
|---|---|
| **Urban Warfare: Detailing Single Building Airflow, Turbulence and Stability Variation Characteristics.** | 5b. GRANT NUMBER |
| | 5c. PROGRAM ELEMENT NUMBER |
| 6. AUTHOR(S) | 5d. PROJECT NUMBER |
| | 5e. TASK NUMBER |
| | 5f. WORK UNIT NUMBER |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **U.S. Army Research Laboratory White Sands Missile Range, NM 88002** | 8. PERFORMING ORGANIZATION REPORT NUMBER |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) | 10. SPONSOR/MONITOR'S ACRONYM(S) |
| | 11. SPONSOR/MONITOR'S REPORT NUMBER(S) |

12. DISTRIBUTION/AVAILABILITY STATEMENT
**Approved for public release, distribution unlimited**

13. SUPPLEMENTARY NOTES
**See also ADM201946, Military Operations Research Society Symposium (73rd) Held in West Point, NY on 21-23 June 2005., The original document contains color images.**

14. ABSTRACT

15. SUBJECT TERMS

| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 18. NUMBER OF PAGES | 19a. NAME OF RESPONSIBLE PERSON |
|---|---|---|---|---|---|
| a. REPORT | b. ABSTRACT | c. THIS PAGE | | | |
| **unclassified** | **unclassified** | **unclassified** | **UU** | **41** | |

# *Urban Warfare:*
# *Detailing Single Building Airflow, Turbulence and Stability Variation Characteristics*

**Gail-Tirrell Vaucher,**
**Ronald Cionco, Manuel Bustillos,**
**Sean D'Arcy, Robert Dumais, SFC Robert Brice**
**U.S. Army Research Laboratory**
**White Sands Missile Range, NM 88002**

# OUTLINE

1. BACKGROUND
   - Military Interest in Urban Atmosphere.
   - Urban Atmosphere: Thermodynamic/Dynamic Patterns.
   - Simplifying the Urban Study.

2. WSMR Urban Study – General Information.
3. 2003 March: Phase I Results Reviewed.

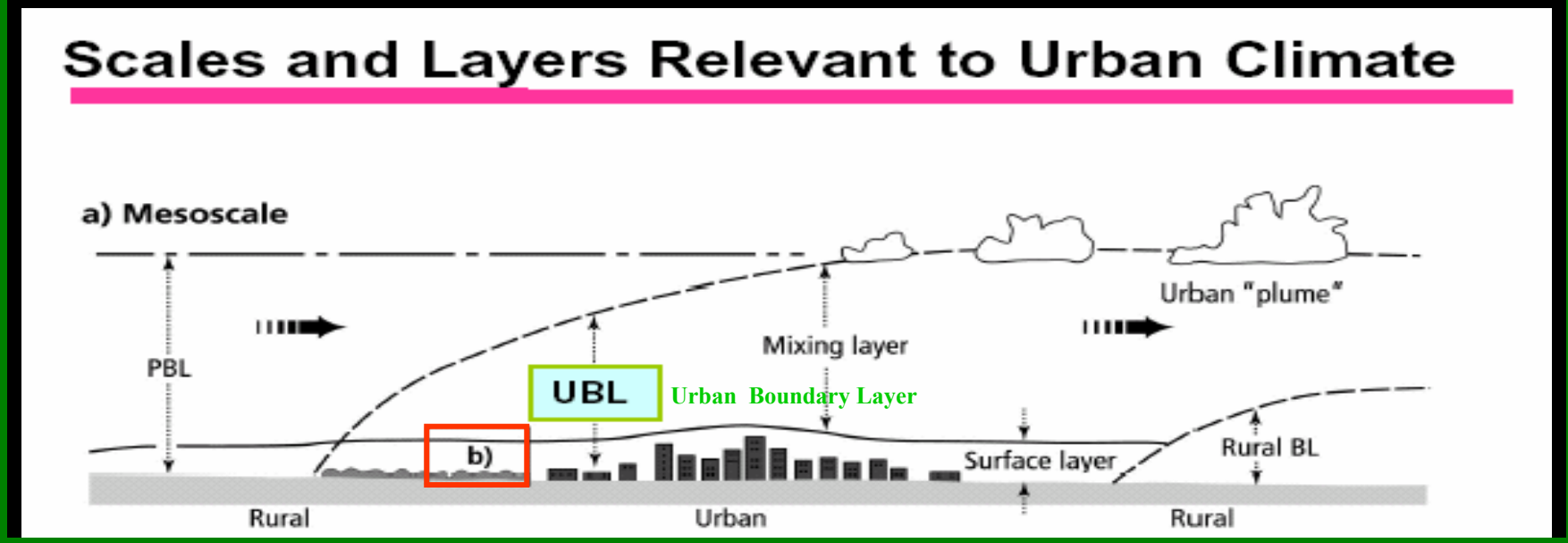
4. 2005 March: Phase II Preliminary Results.

# 1. BACKGROUND
## Military Interest in Urban Atmospheric.

- **CALL Newsletter No. 99-16**, Chapter 9 (*Flight Operations in Urban Areas*); Observation 16 (Environmental Considerations).
  - **Winds**
    - Broken up winds, funneled down street/alley.
    - Turbulence in canyons impact aircraft performance & weapon delivery.
  - **Temperatures**
    - Thermal heating affected by buildings (can be 10-20C warmer than rural).
    - Adversely affect thermal sights on aircraft.
  - **Visibility**
    - Smog reduces visibility, increases target acquisition/threat exposure time.
    - Weapon sensors degraded; laser guided weapons "severely affected".

- ***Aviation Urban Operations Manual*** –Joint Air, Land, Sea Applications Center
  - **Wind Patterns**: Mission Planning Factors.
    - Degraded Night Vision Systems. [UHI effect also].
    - Degraded communications.
    - Degraded Visibility and Toxic Fumes.

# 1. BACKGROUND
## Urban Atmosphere



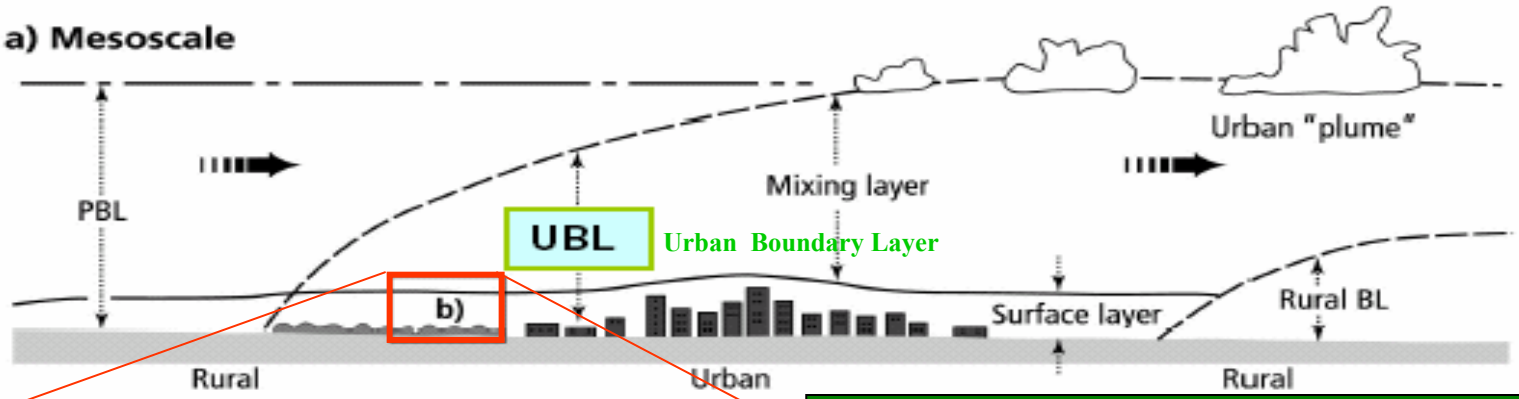

Ability to simulate the urban atmosphere is dependent upon understanding urban

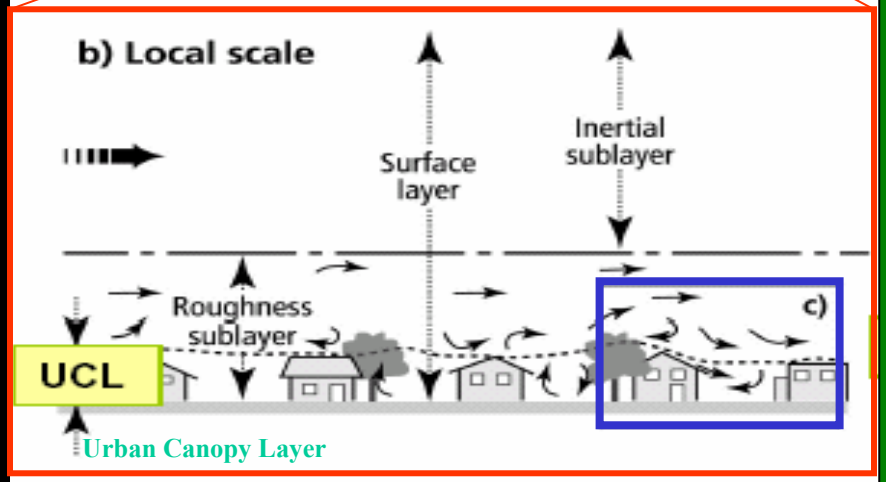
- dynamic airflow behavior and
- thermodynamic properties,

above and about buildings and their surroundings.

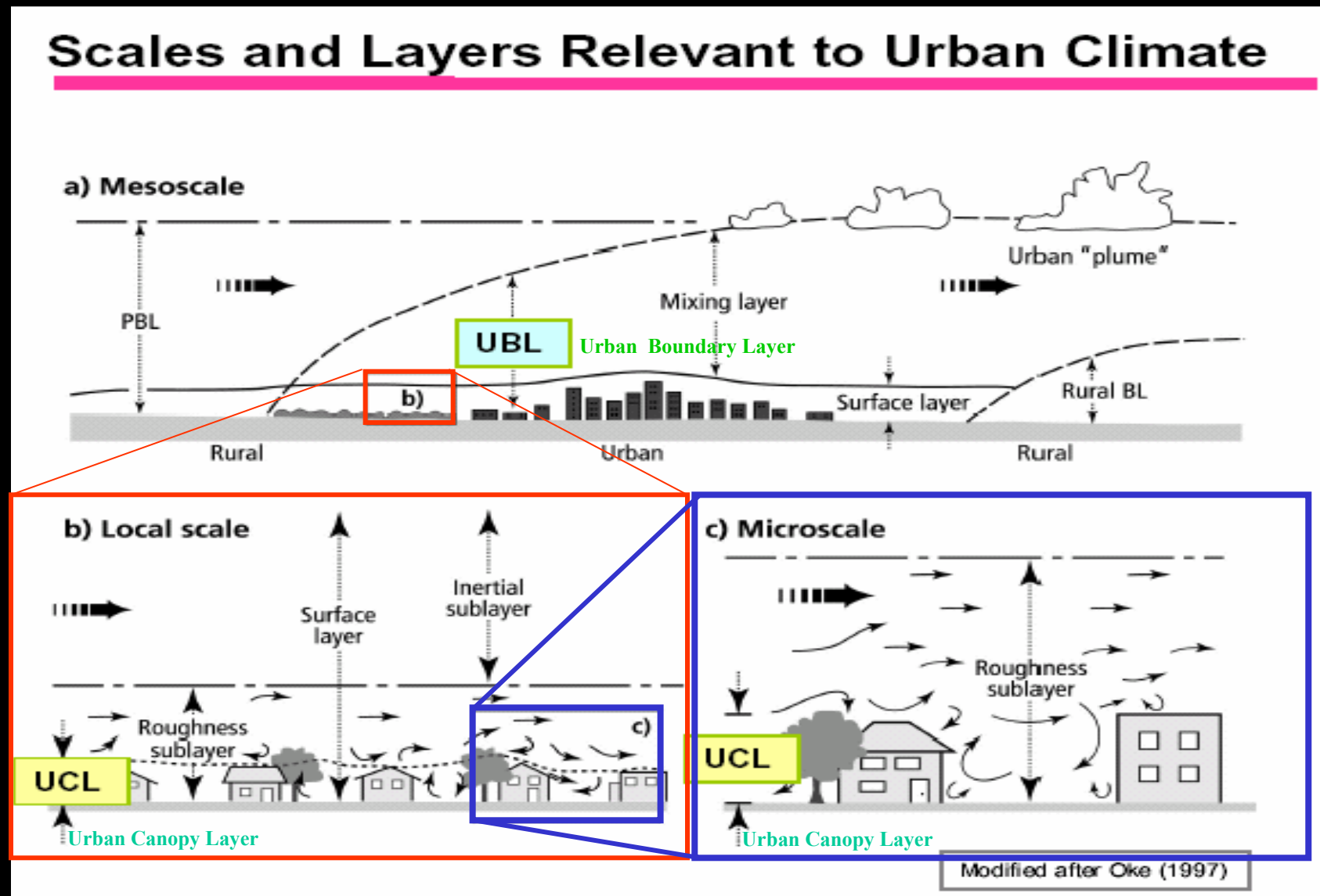
# 1. BACKGROUND
## Urban Atmosphere

### Scales and Layers Relevant to Urban Climate

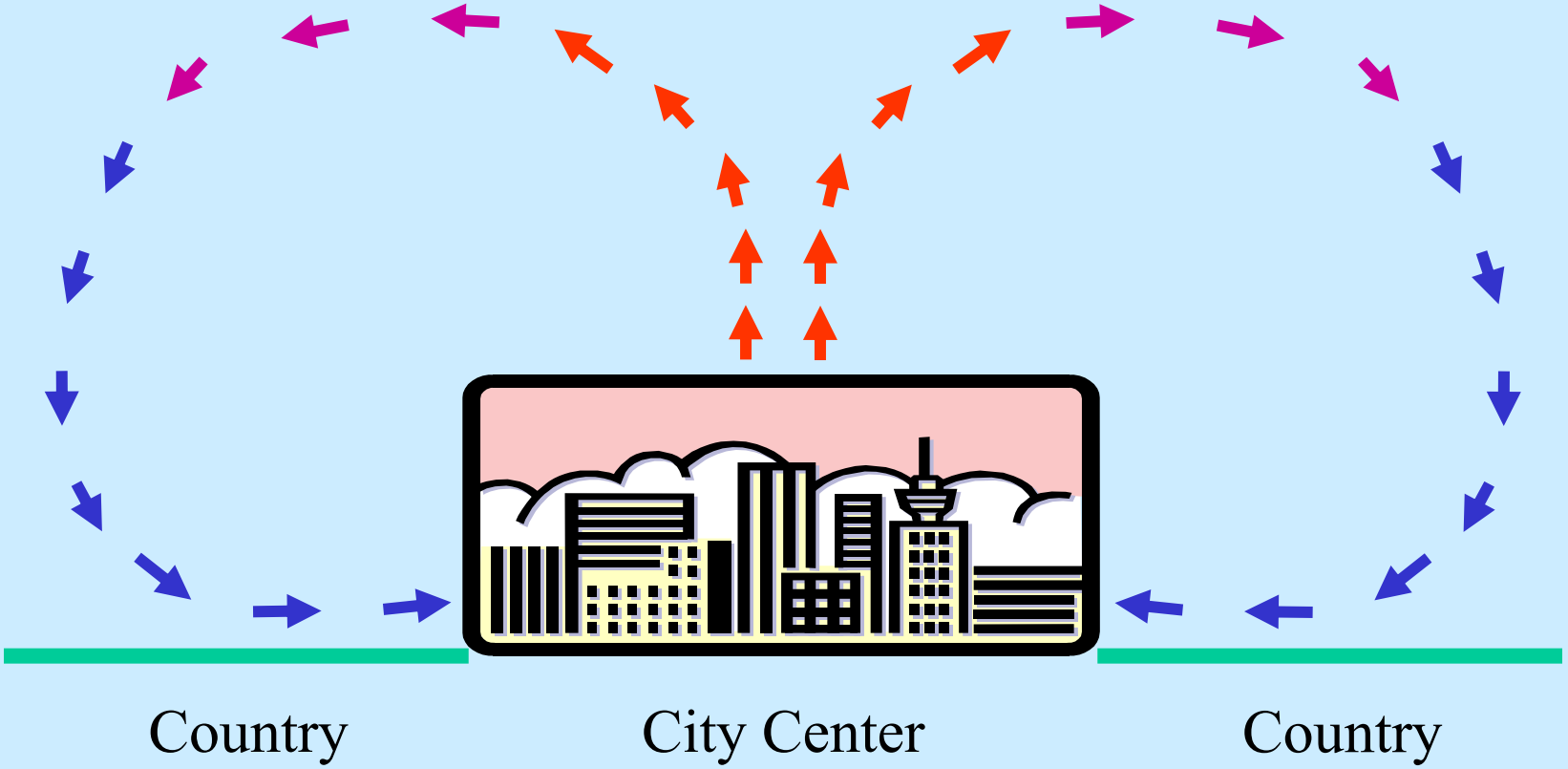



# 1. BACKGROUND
## Urban Atmosphere

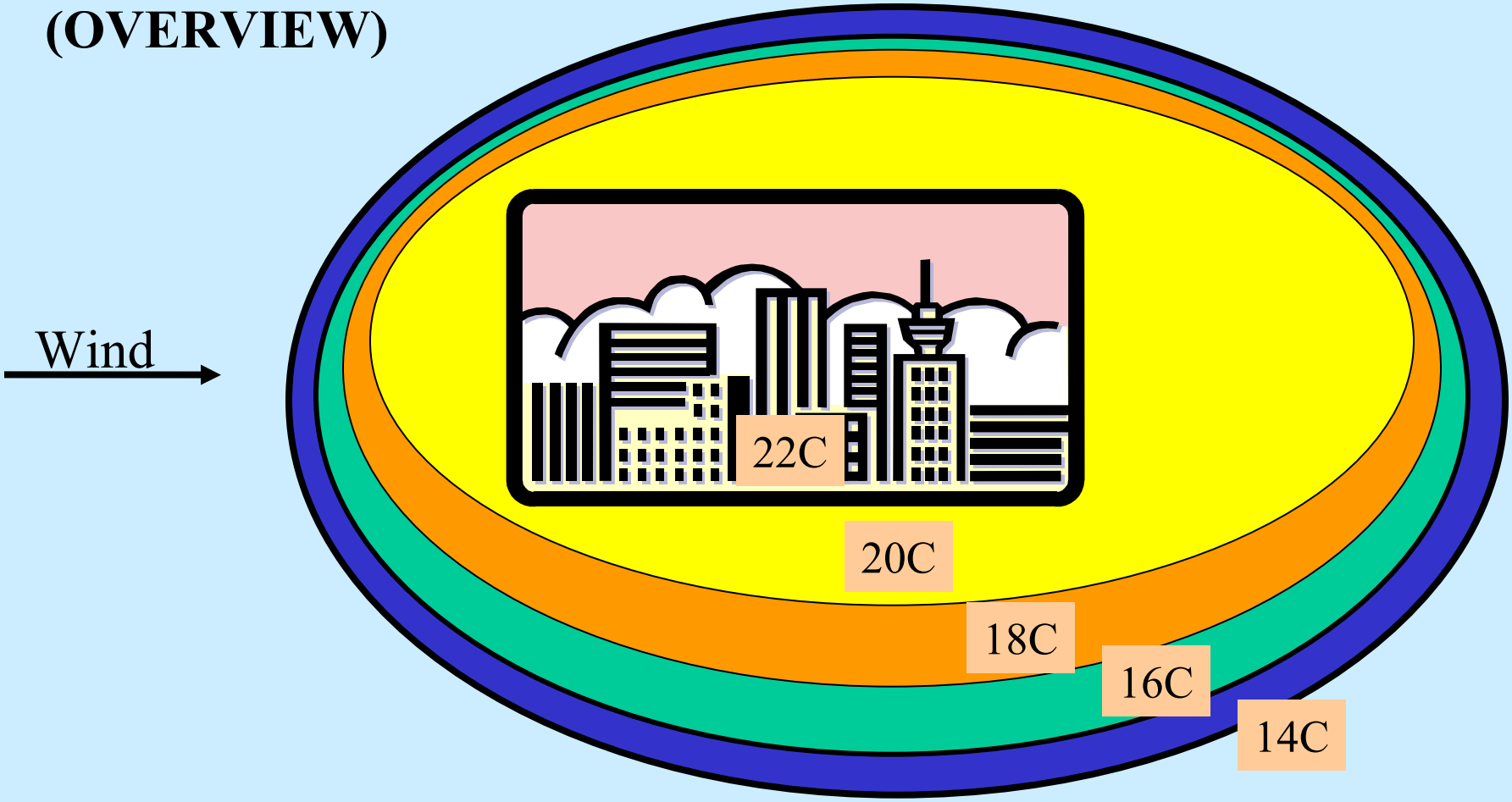


# 1. BACKGROUND
## Urban: Thermodynamic Patterns.



# 1. BACKGROUND
# Urban: Thermodynamic Patterns.

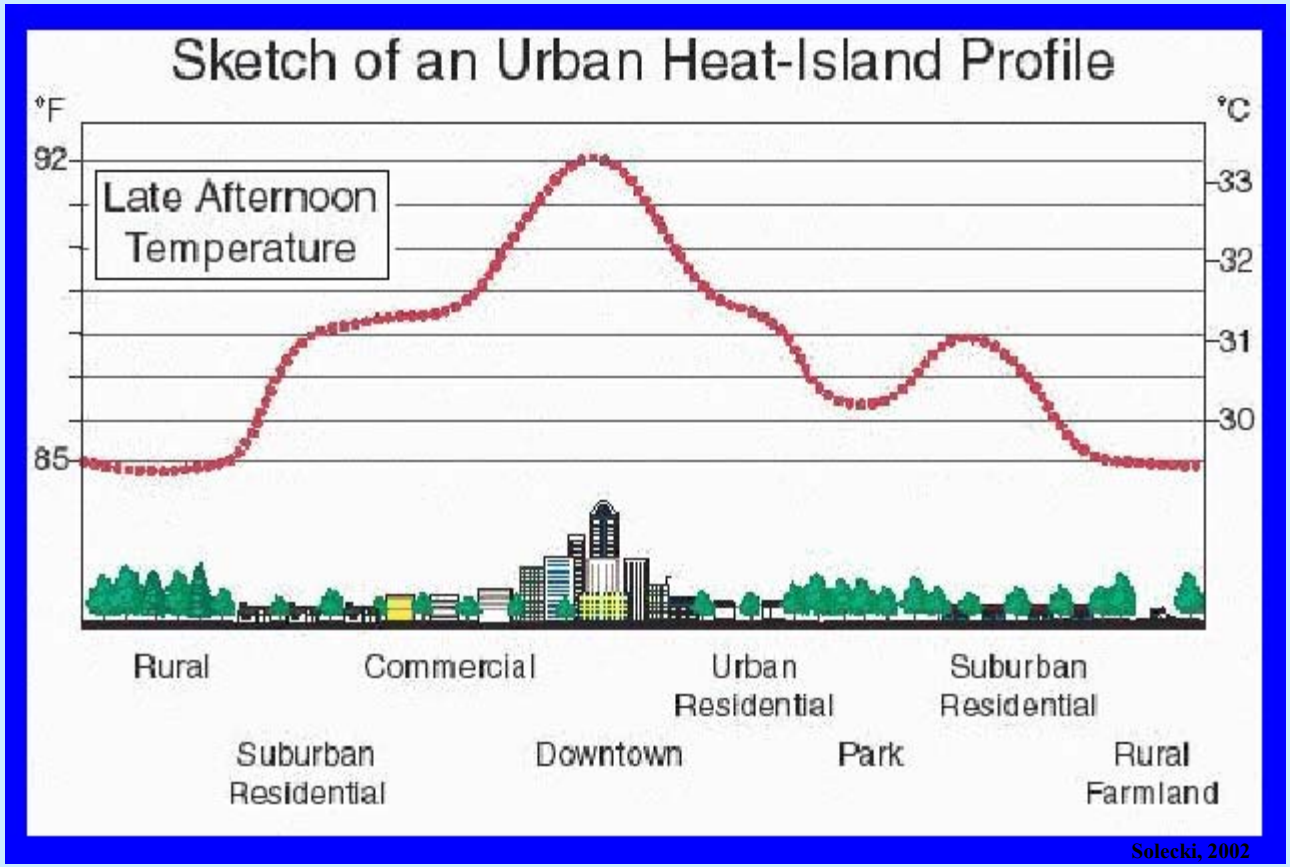
**(OVERVIEW)**




Luke Howard – First to discover Urban Heat Island [UHI].
Gordon Manley (1958) - First English Pub with UHI

# 1. BACKGROUND
# Urban: Thermodynamic Patterns.

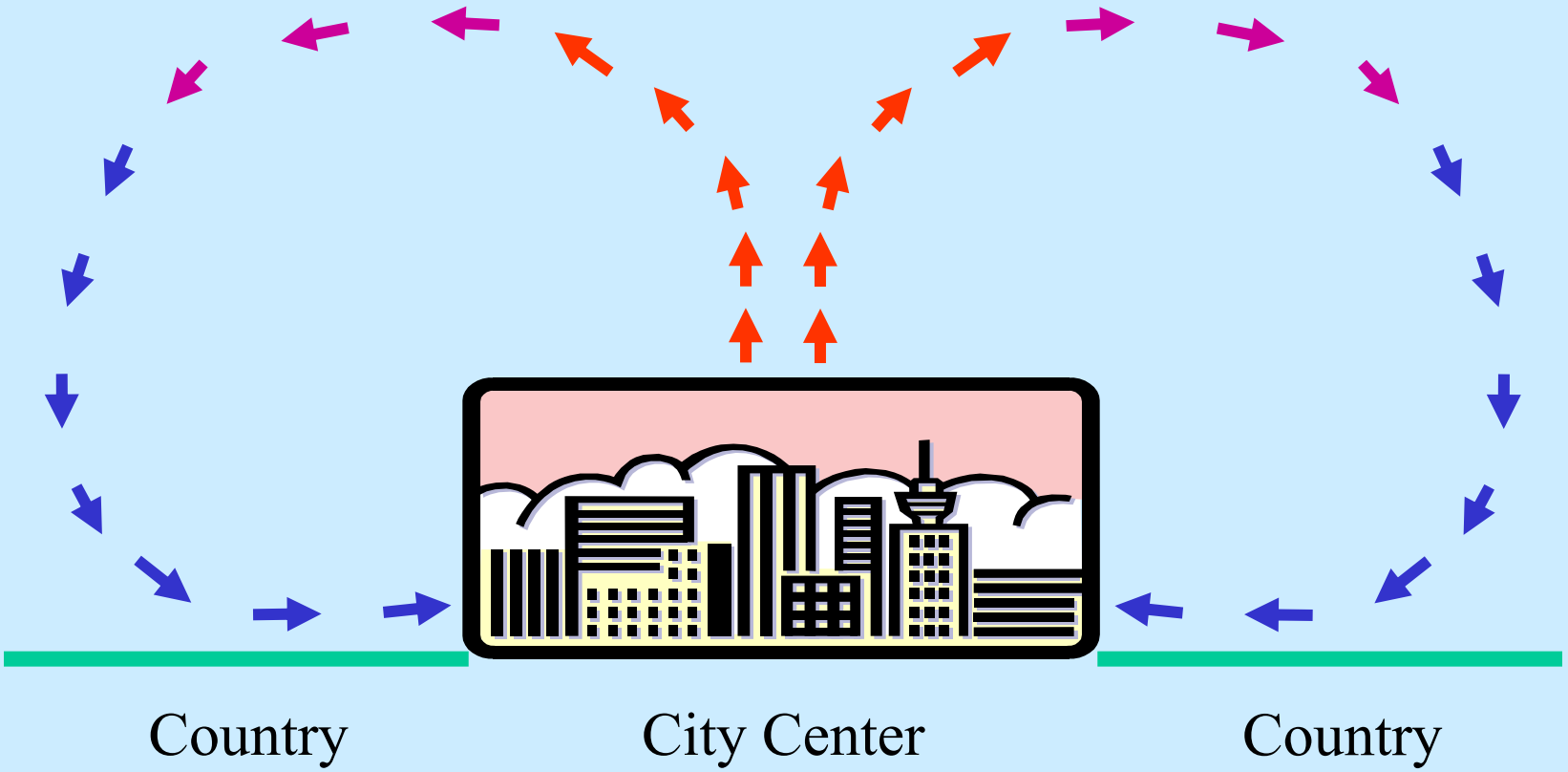
**Vertical cross-section**




**U.S. Dept of Energy:**

**"On warm summer days, the air in a city can be 6-8°F hotter than the surrounding countryside."**

# 1. BACKGROUND
## Urban: Thermodynamic/Dynamic Patterns.



# 1. BACKGROUND: Dynamic Patterns. Channeling/Canyon Flow/Complex Flow


*side view*

# 1. BACKGROUND: Dynamic Patterns. Complex Airflow around Tall Buildings

**Complex Airflow around Tall Buildings and…**

**Short Buildings…**

# 1. BACKGROUND: Dynamic Patterns. Simplifying the Urban Study

**Reduce problem to two options:**

1. **Multiple buildings (city downtown areas) and**
2. **Single buildings (large store/factory/office bldg and parking lot).**



Wal-Mart Supercenters range from 109,000 square feet to more than 260,000 square feet and offer shoppers a wide variety of goods and services.

Hundreds of Wal-Mart stores feature gasoline outlets like this Murphy Oil USA facility in Siloam Springs, Ark.

## 2. WSMR Urban Study

# *Air Flow and Stability Variations Around a Single Building*

- **2003 March Field Test – Mean Flow/Stability.**
- **2005 March Field Test – Turbulent Conditions.**

# 2. WSMR Urban Study

## Wind Tunnel Flow Fields, Snyder and Lawson, 1994

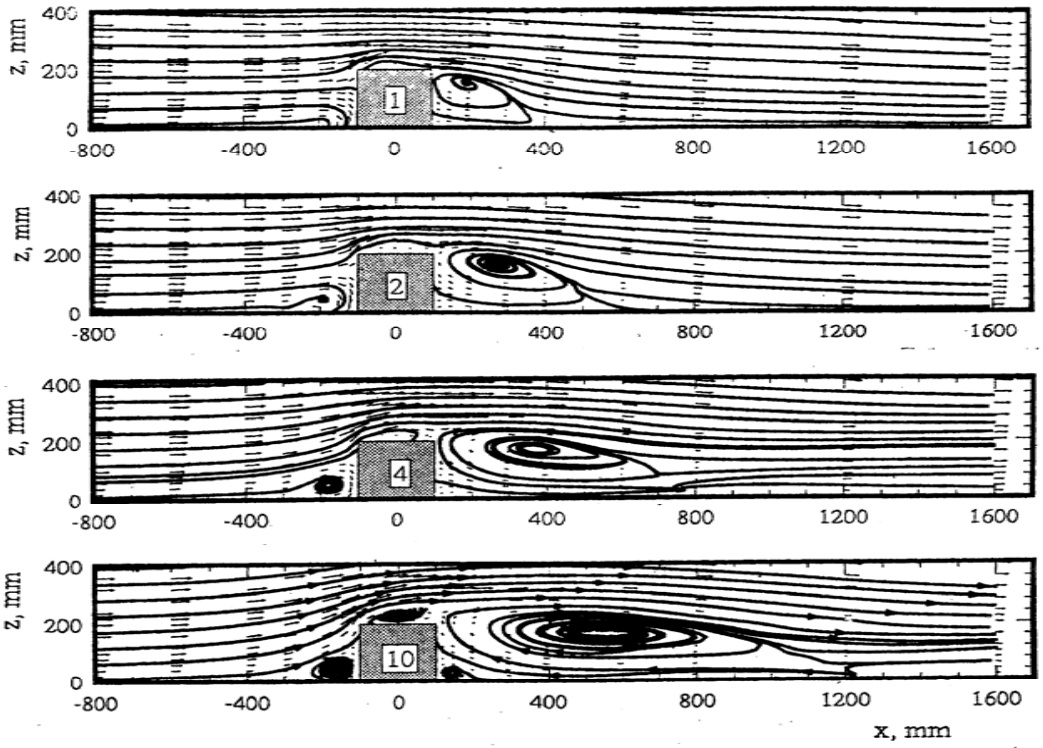
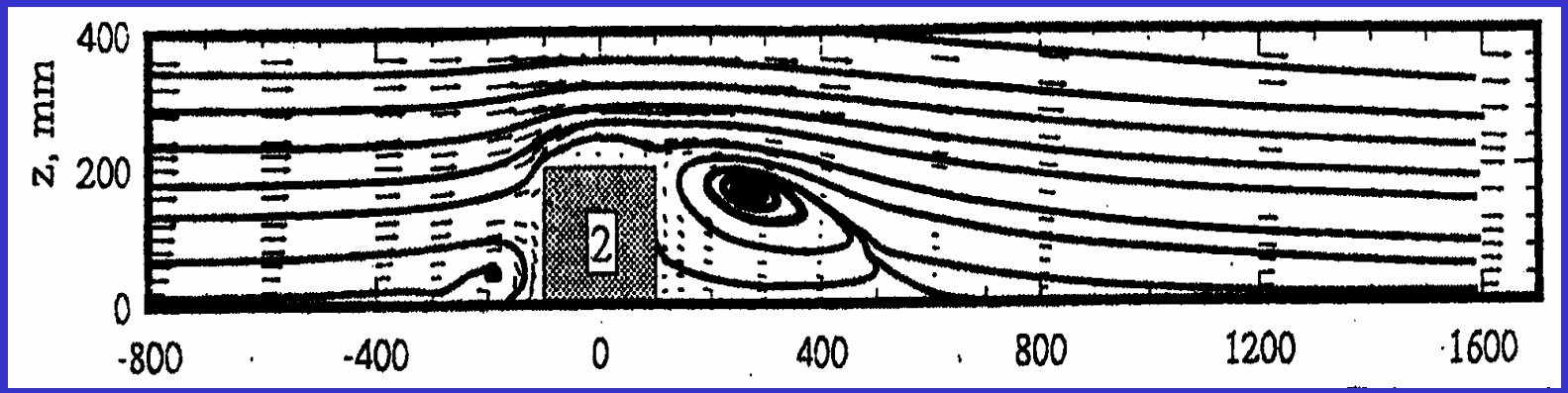



Figure 2. Streamline patterns around buildings of various crosswind widths. Number on building is W/H. L=H.

# 2. WSMR Urban Study

Accelerated Flow

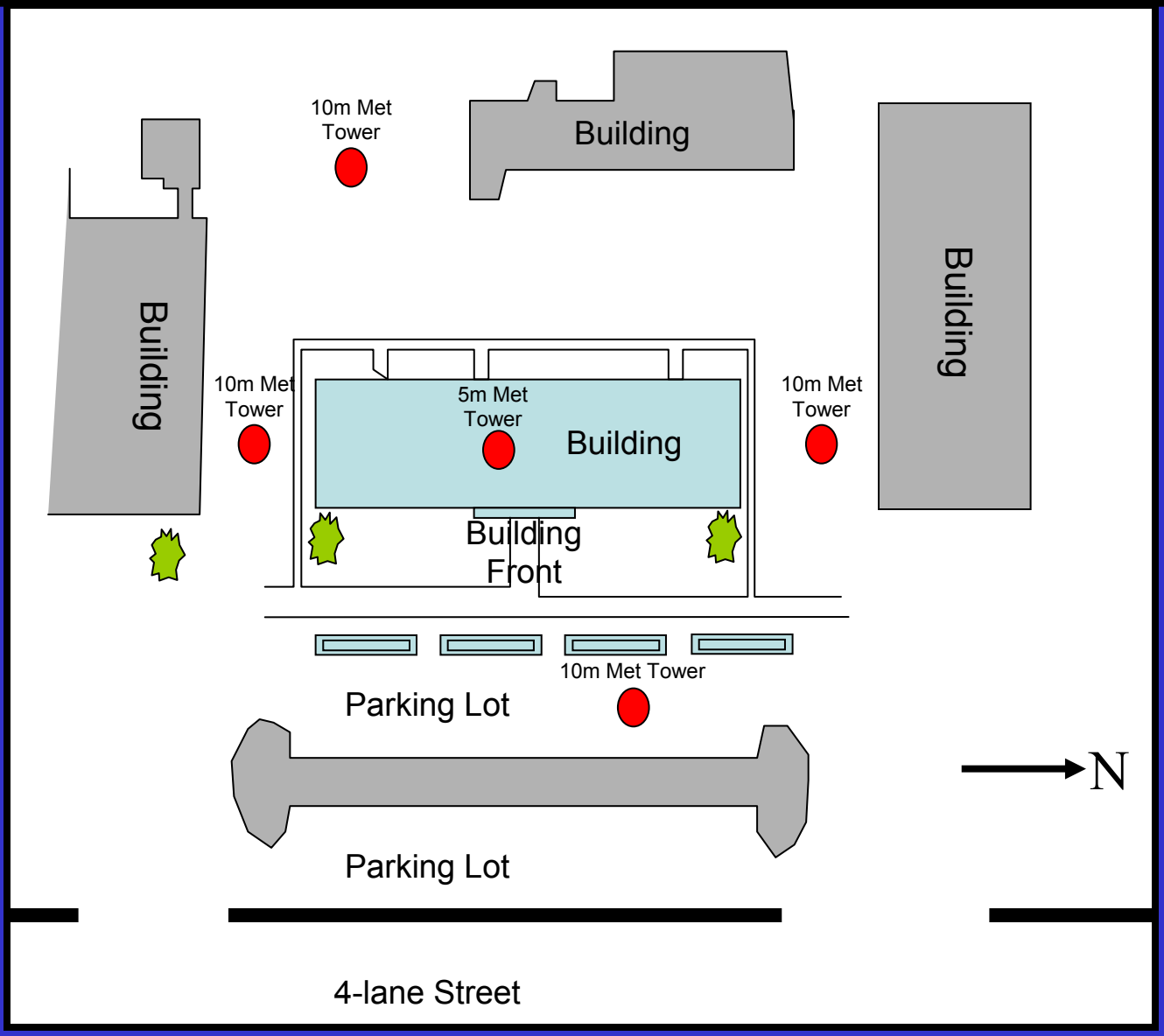
Velocity Deficit




Fetch flow

Flow Reversal

# Field Site Layout
# (Not drawn to scale)



# 3. 2003 March: Phase I Results Reviewed.

## Air Flow

➲**Results presented in 3 perspectives:**

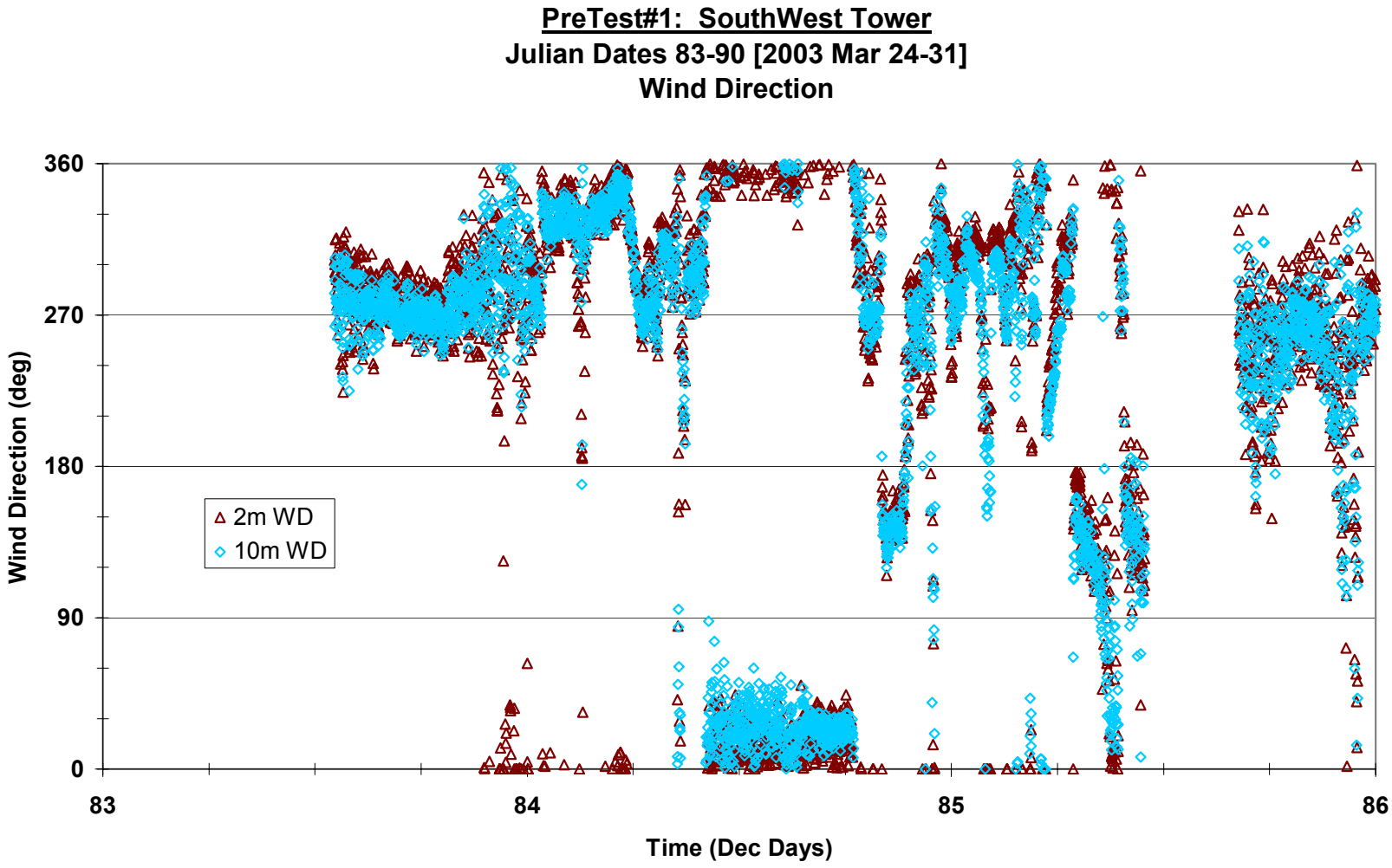
- Numerically (Measurement Sample)
- Graphically (Time series)
- Visually (Photograph)

**Strong West Winds Case (JD 86.422)**

| TWR: | SW | ROOF | EAST | NORTH | SOUTH | |
|---|---|---|---|---|---|---|
| 10M: | 13.64 | 14.54 | W 8.4 | 14.6 | 15.4 | m/s |
| 2M: | 7.1 | ---- | E 2.8 | 9.22 | 11.7 | m/s |

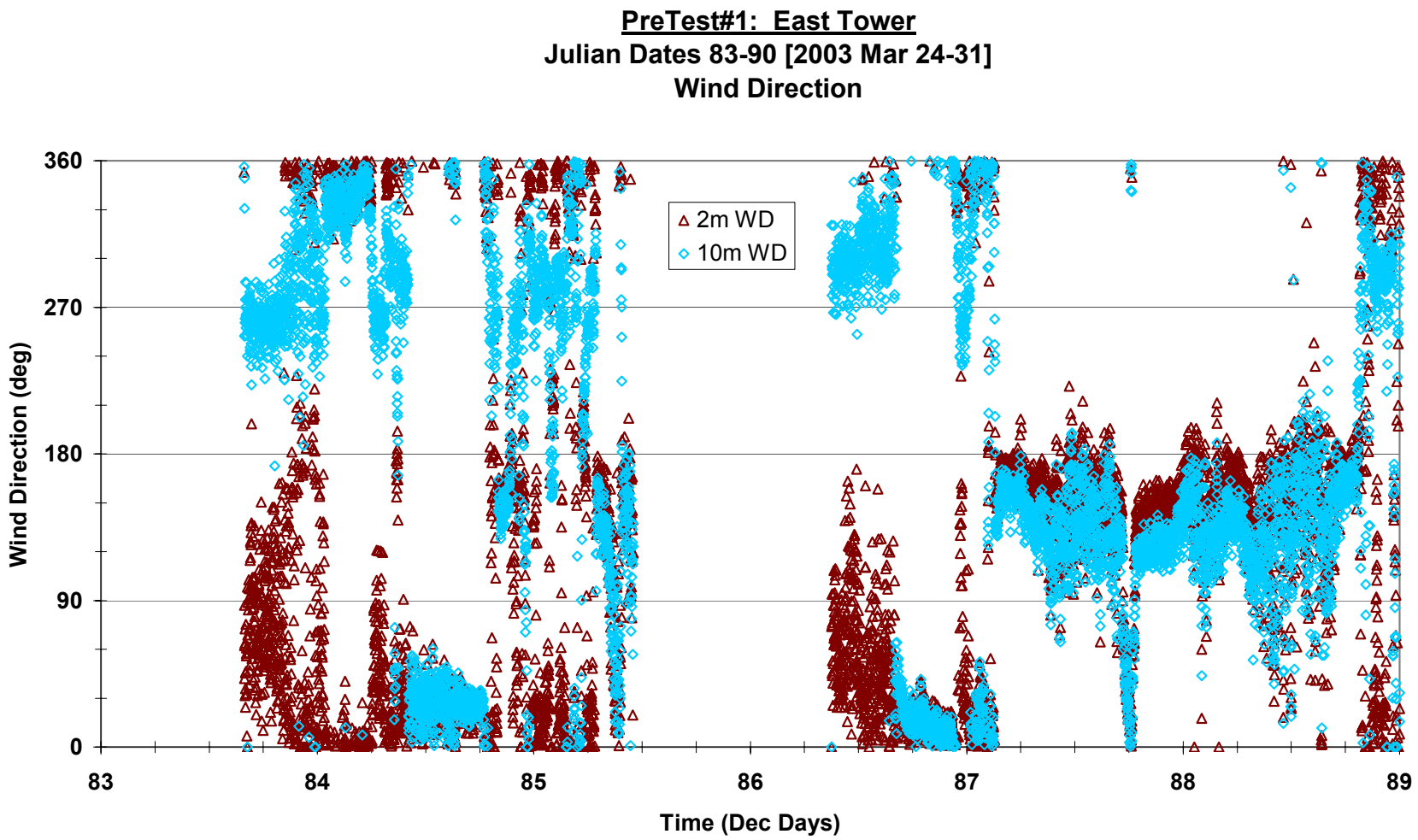
# 3. 2003 March: Phase I Results Reviewed.

## Southwest Tower: UPWIND CONDITIONS



# 3. 2003 March: Phase I Results Reviewed.

## East Tower: DOWNWIND OF BUILDING



# 3. 2003 March: Phase I Results Reviewed.

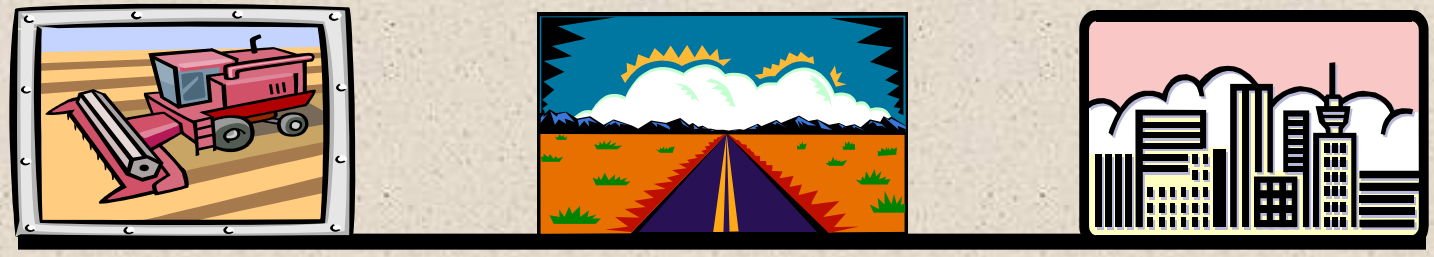
**East Tower:**

**BUILDING LEESIDE CAVITY ZONE**

# 3. 2003 March: Phase I Results Reviewed.

## Stability Variations

$T_{Rural}$ $T_{Urban}$



**Rural Pattern**

**Day - Unstable**

**Night – Stable**

**Transitions = two.**

**2003 Mar 12**

**Urban Pattern**

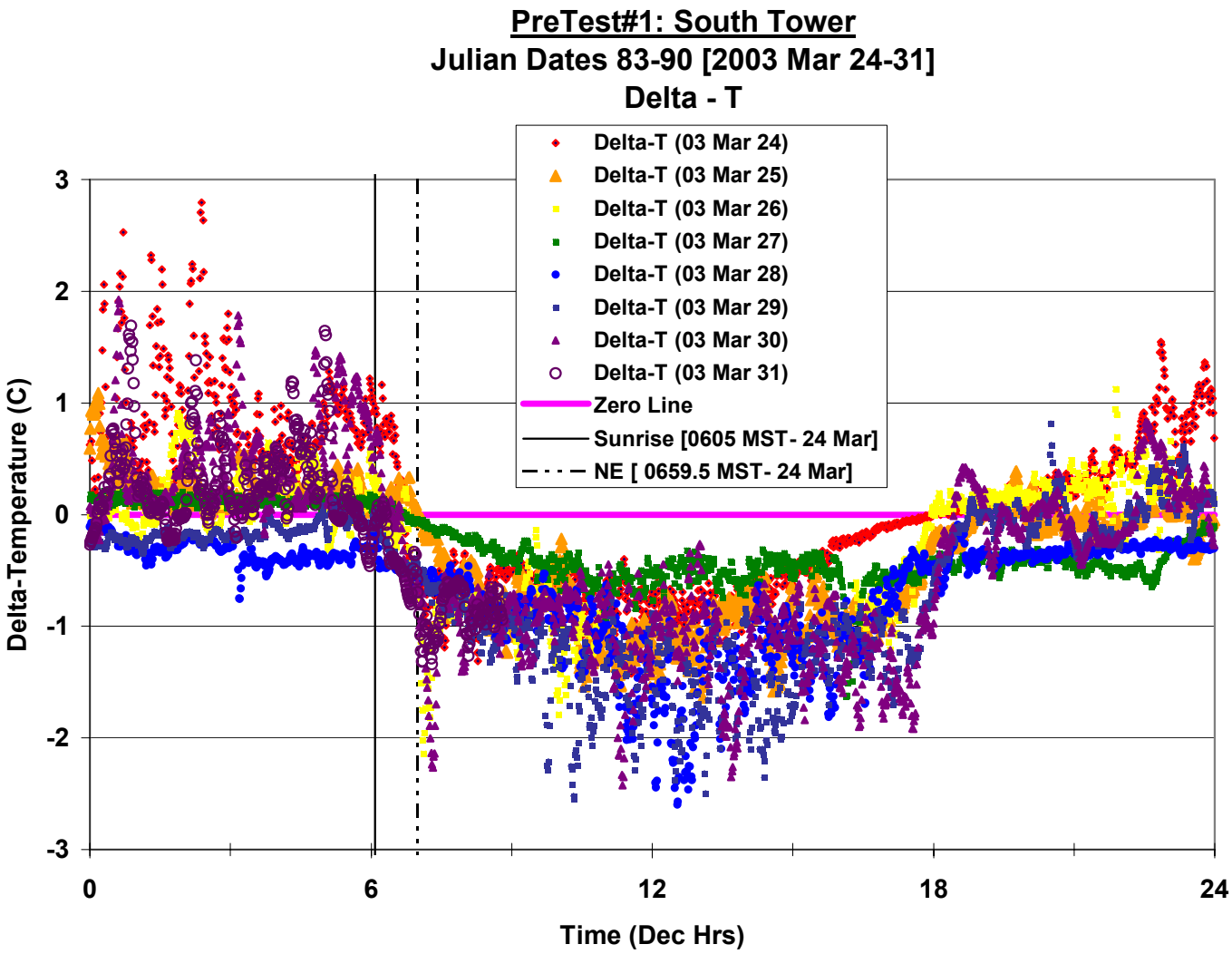
**Day – Unstable**

**Night – Unstable/Neutral**

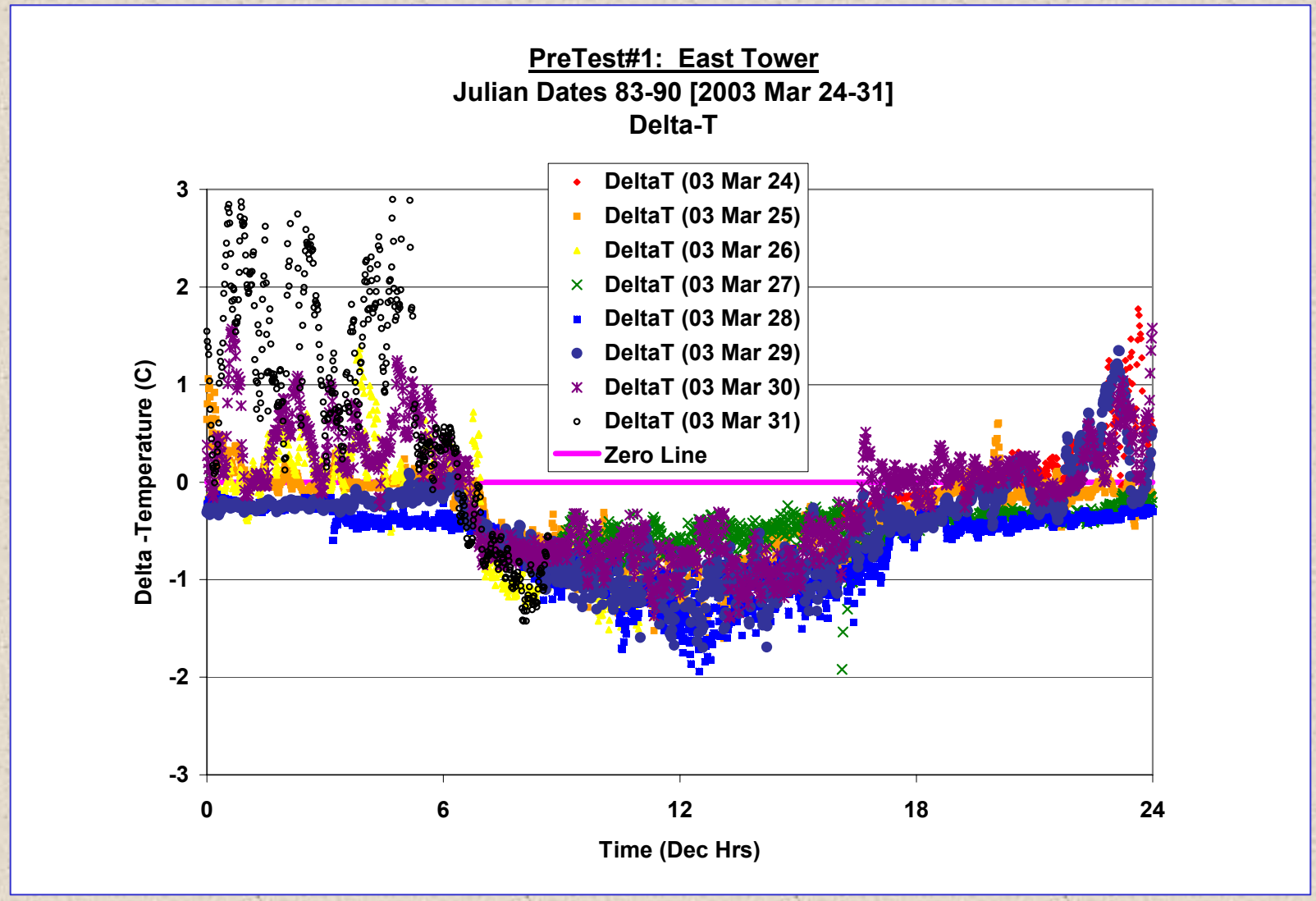
**Transitions = Intermittent.**

**2003 Mar 25-31**

# 3. 2003 March: Phase I Results Reviewed.



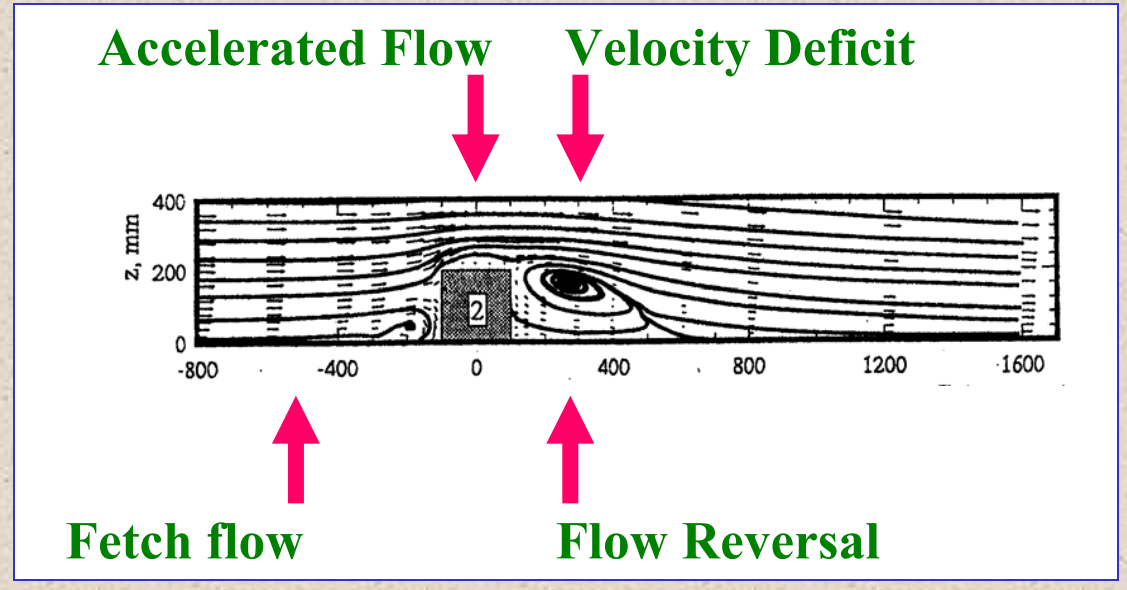
# 3. 2003 March: Phase I Results Reviewed.



# 3. 2003 March: Phase I Results Reviewed.

➲ **Air Flow Results:**

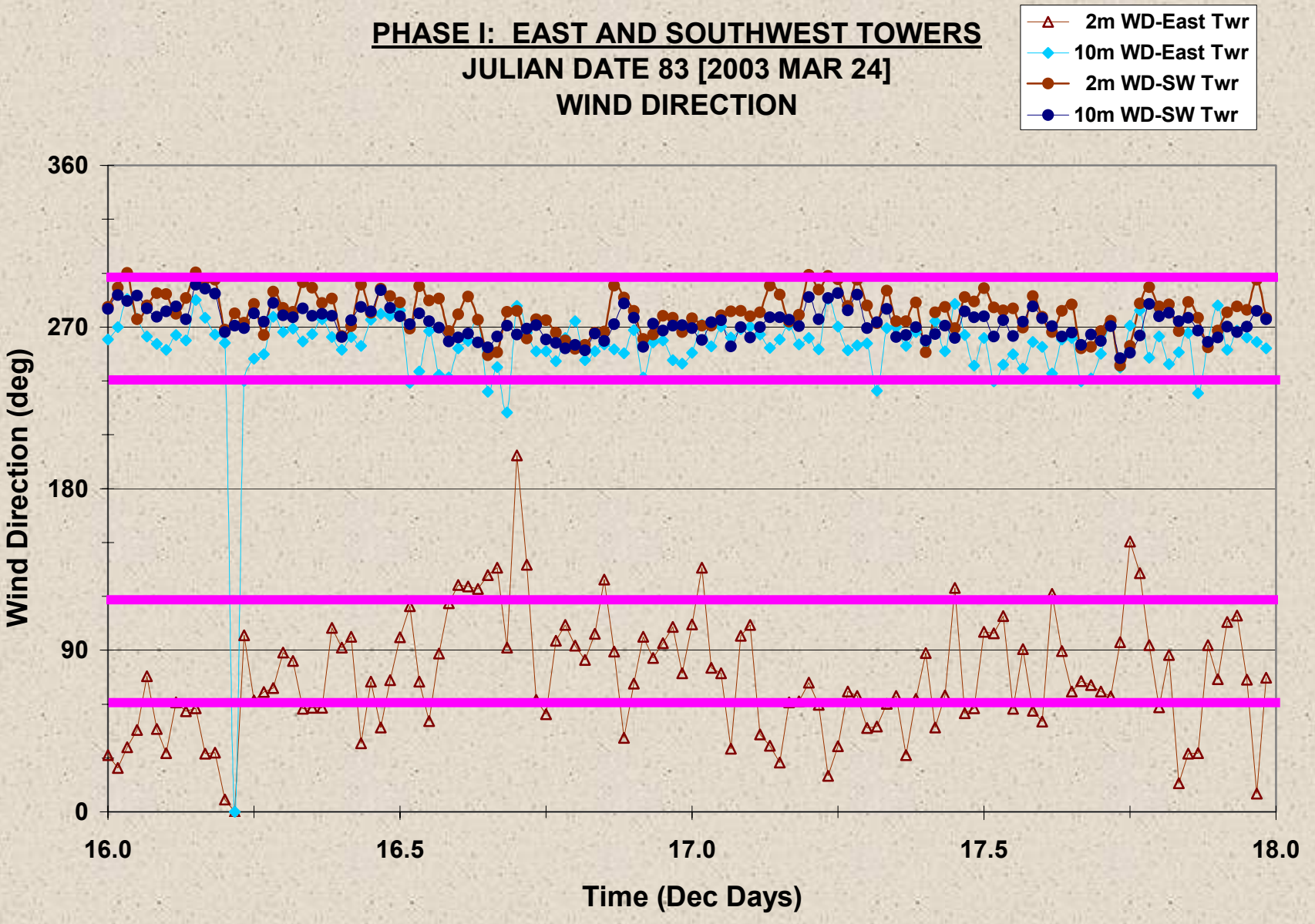
- **Validated Specific Wind Tunnel Air Flows Features.**
- **Single building affects air flow patterns.**




➲ **Stability Transition [ST] Results:**

- **ST results characterize an Urban Heat Island [UHI] effect.**
- **Small building complexes can retain some rural atmospheric character.**

# 4. 2003 March: Phase II (Background)



# 4. 2005 March: Phase II (Study Specifications).

- **March 2003**: Mean Meteorological Conditions.
- **March 2005**: Flow and Stability under Turbulent Conditions.

- **Mission Objectives**: to characterize urban Airflow and Stability Patterns around and above a single building.

- **Field Study Design**:
  - Location- Single, 2-story, rectangular, concrete-block office building.
  - 5 Meteo Towers- 10m N-,S-,E-,and W-sides; 5m roof.
  - Tower Placement- Synder & Lawson wind tunnel study.
  - Sensors- Sonic and Campbell Systems.
  - Variable- P, T, RH, WS/WD, Solar Radiation.

# 4. 2005 March: Phase II (16 Sonics Added).

## 1 Minute Averages

## 20Hz Sampling Rate

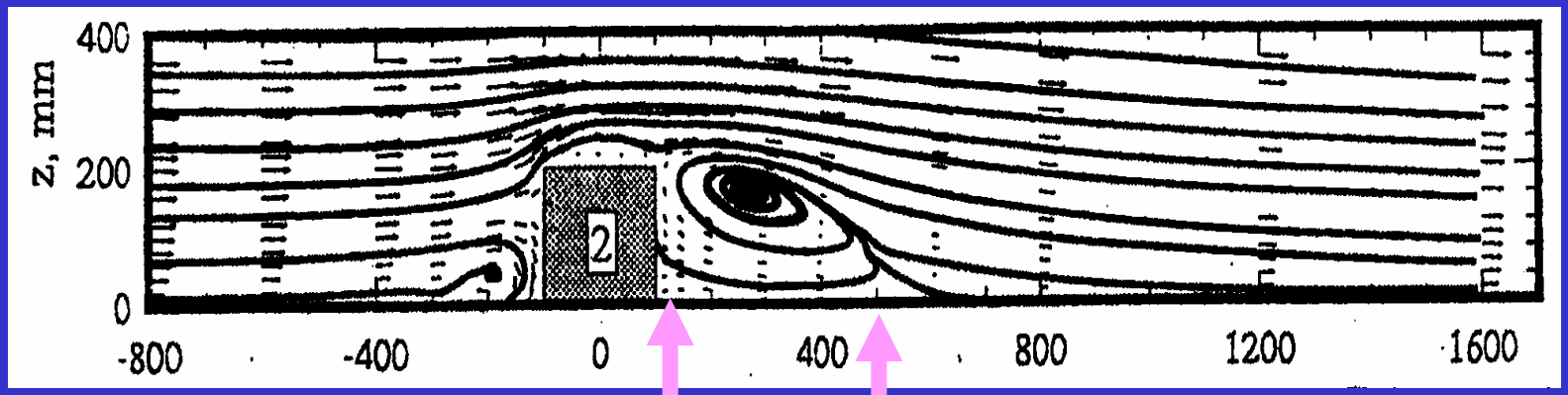
# WSMR Urban Study

## BUILDING and TOWERS

# 2. WSMR Urban Study

Accelerated Flow

Velocity Deficit



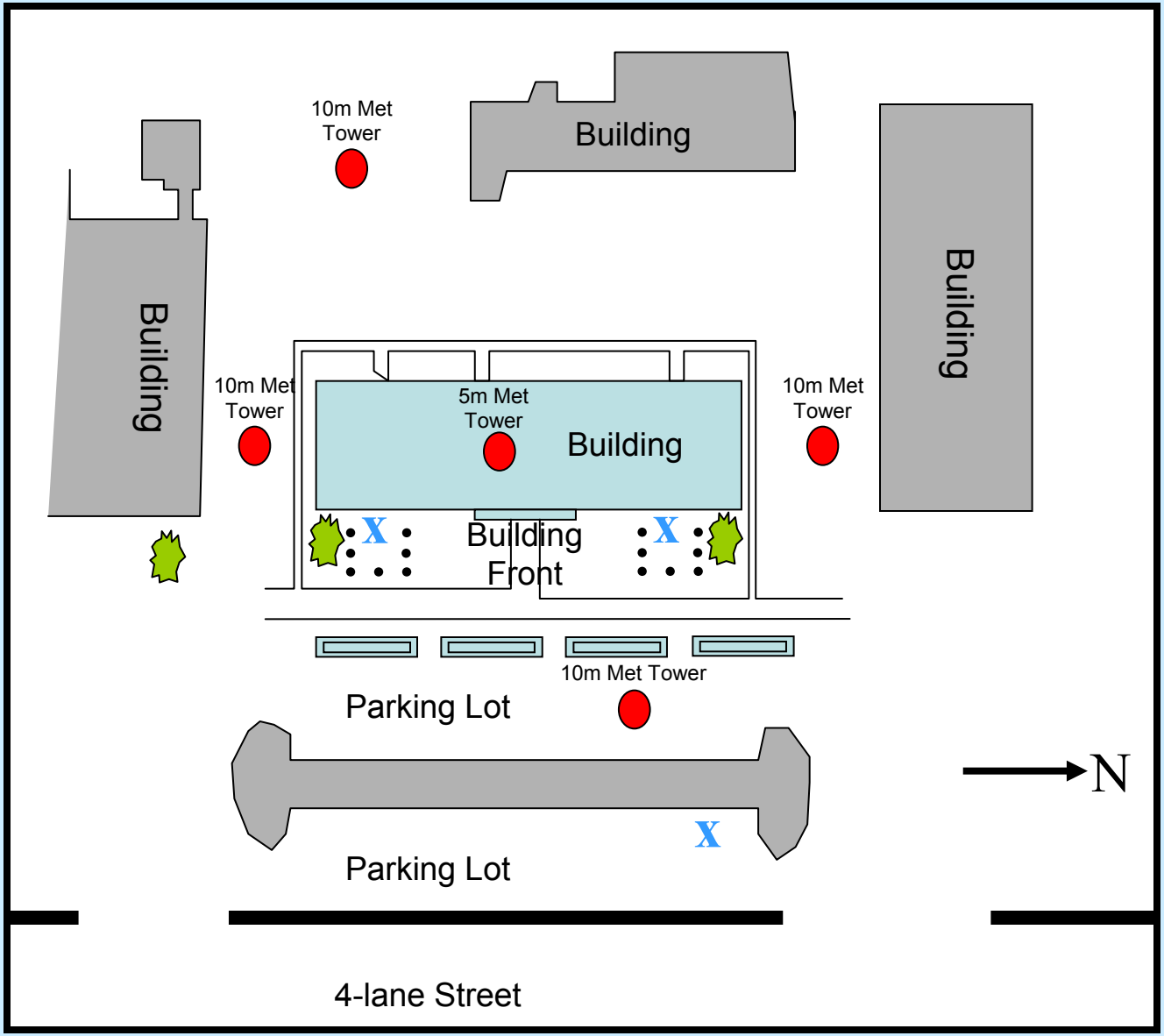

Leeside Eddies

Re-attachment Zone

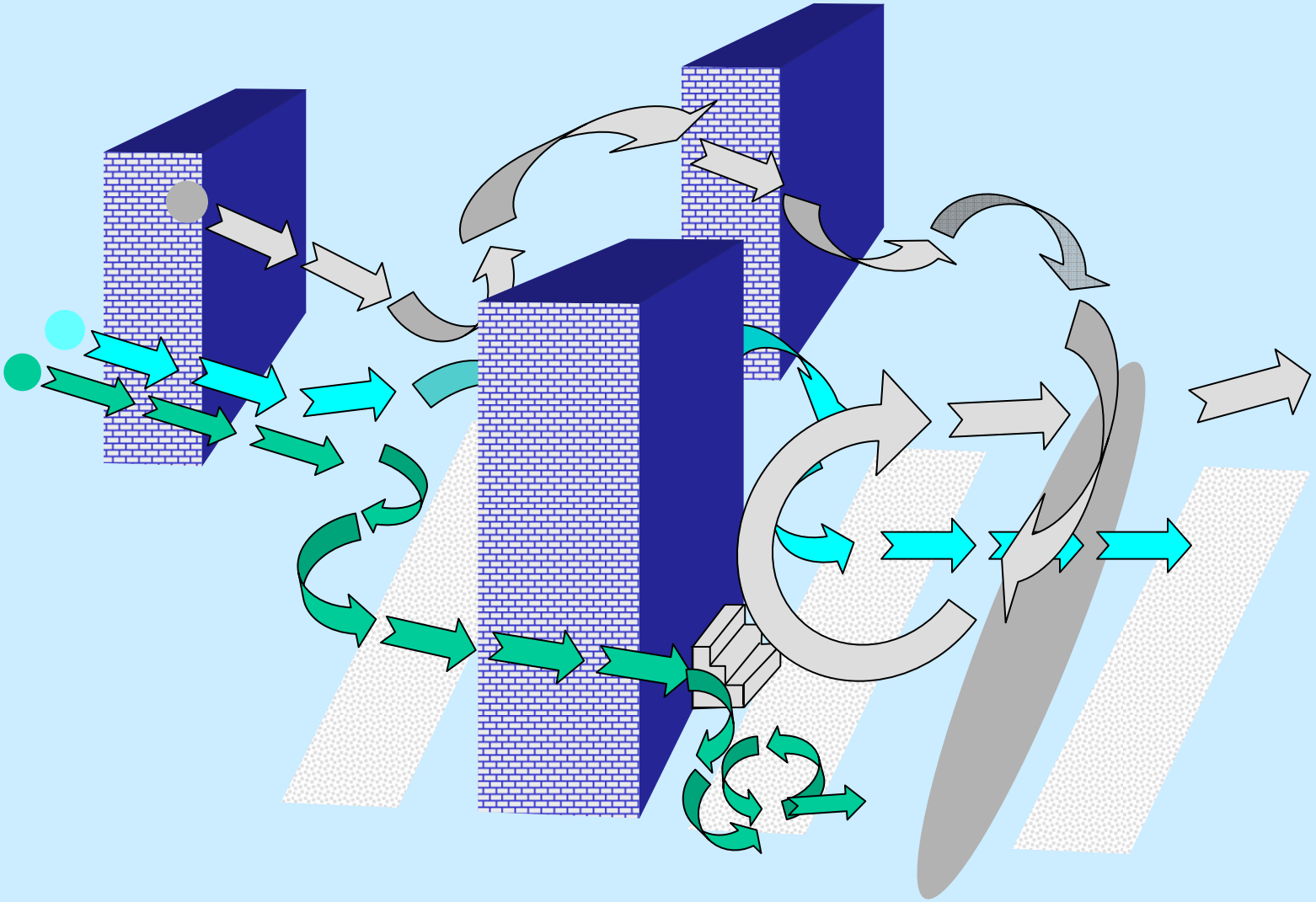
Fetch flow

Flow Reversal

# Phase II: Field Site Layout
# (Not drawn to scale)

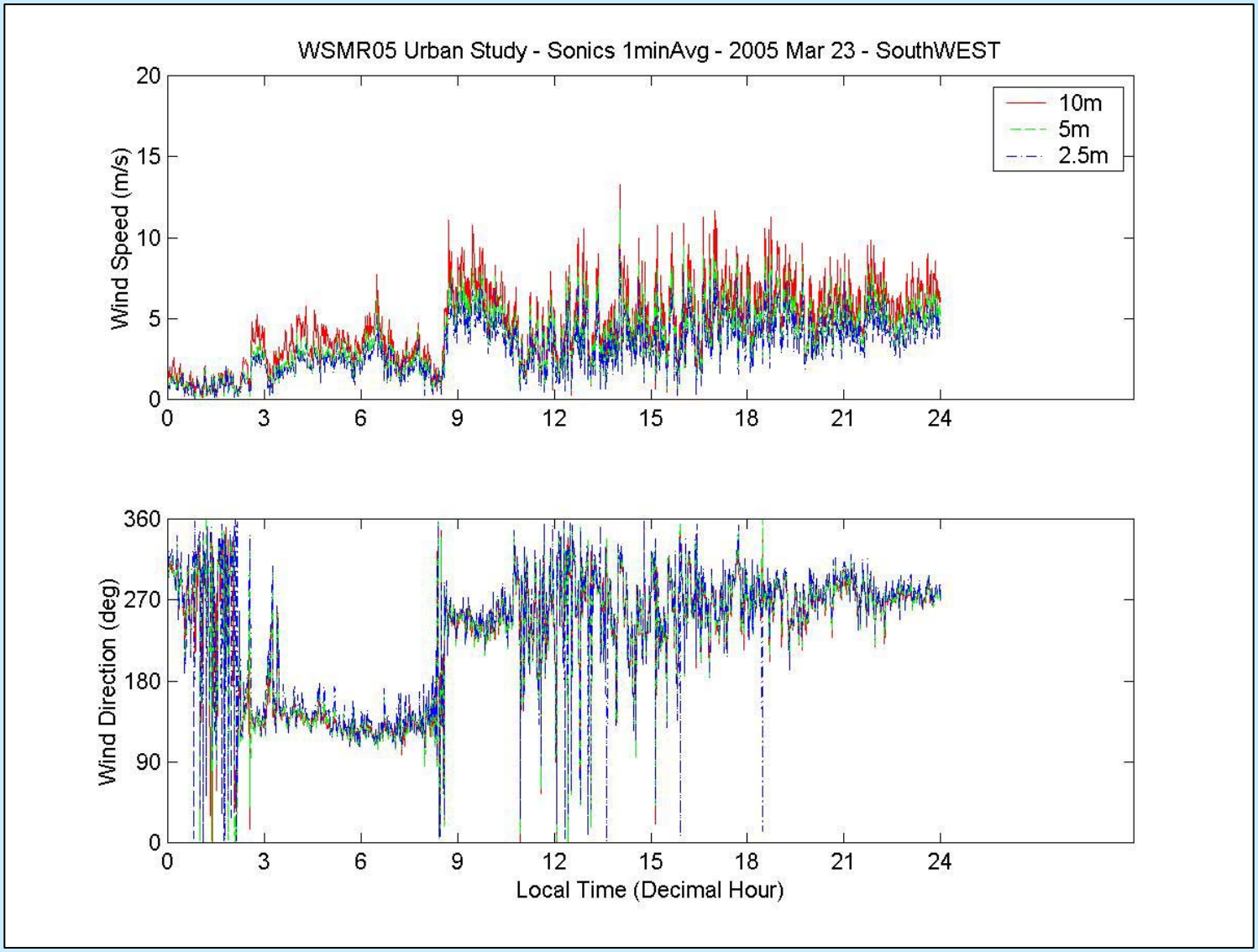


# 4. 2005 March: Phase II (Turbulent Conditions).



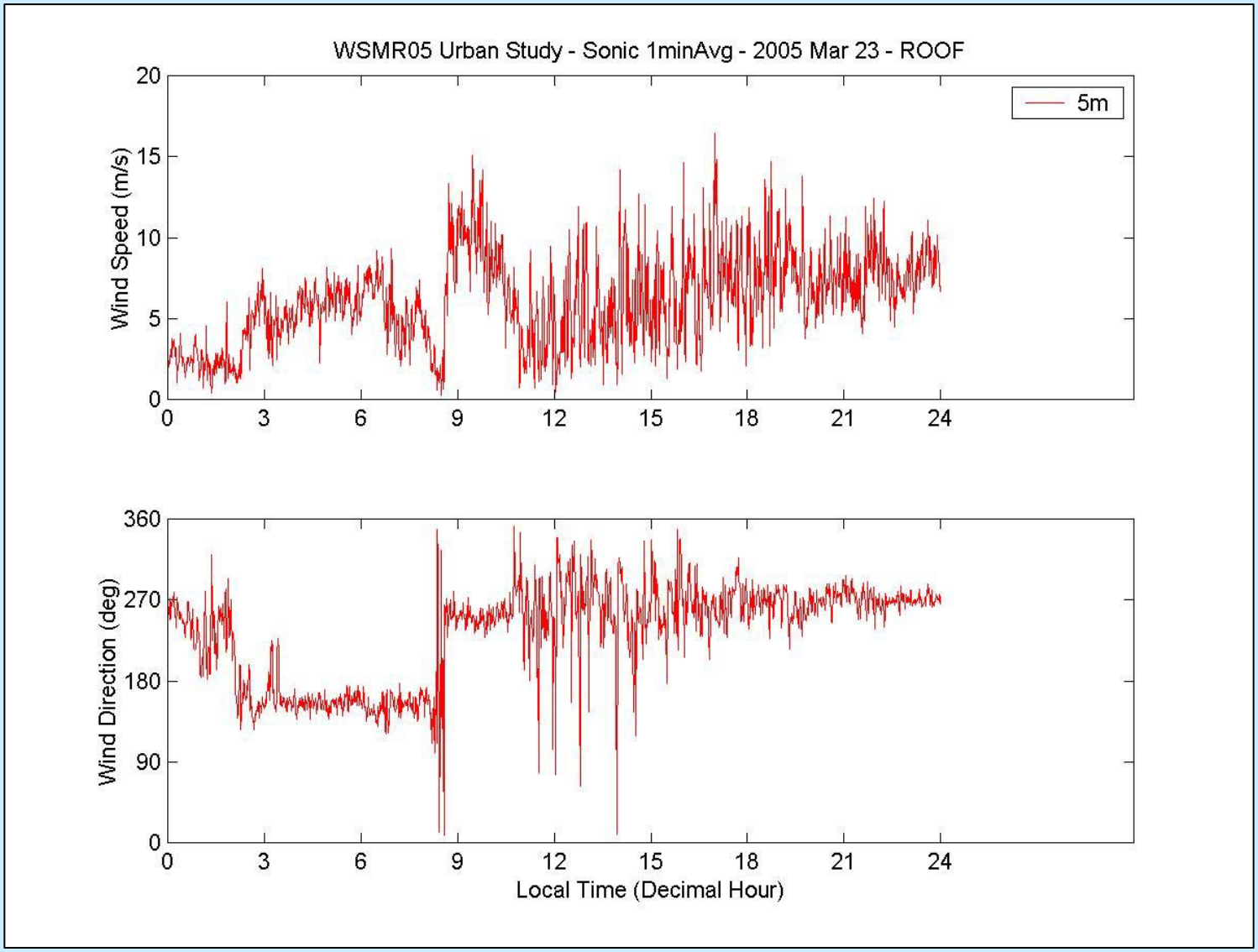
# 4. 2005 March: Phase II Preliminary Results.

## "THE FETCH"



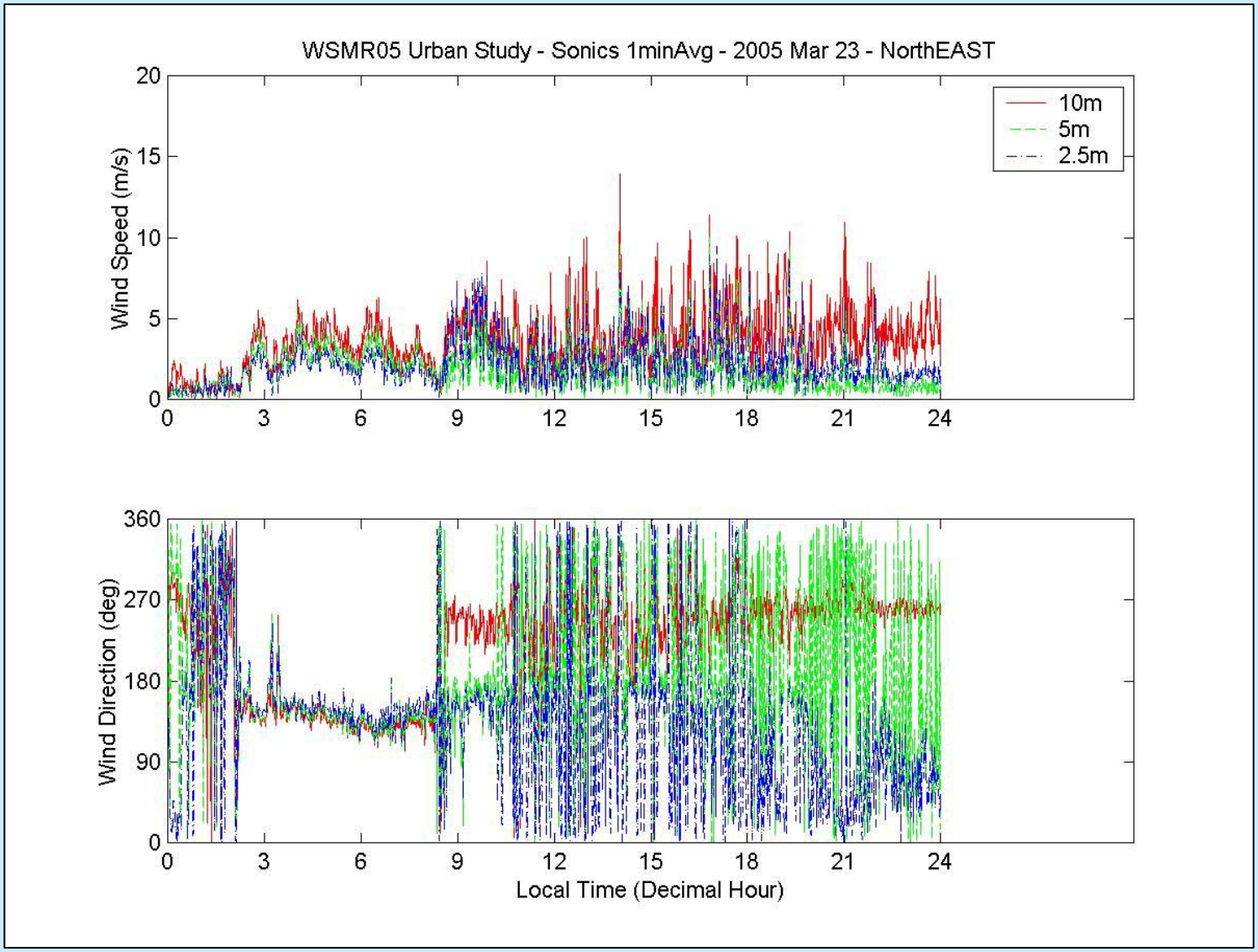
# 4. 2005 March: Phase II Preliminary Results.

## "THE ROOF"



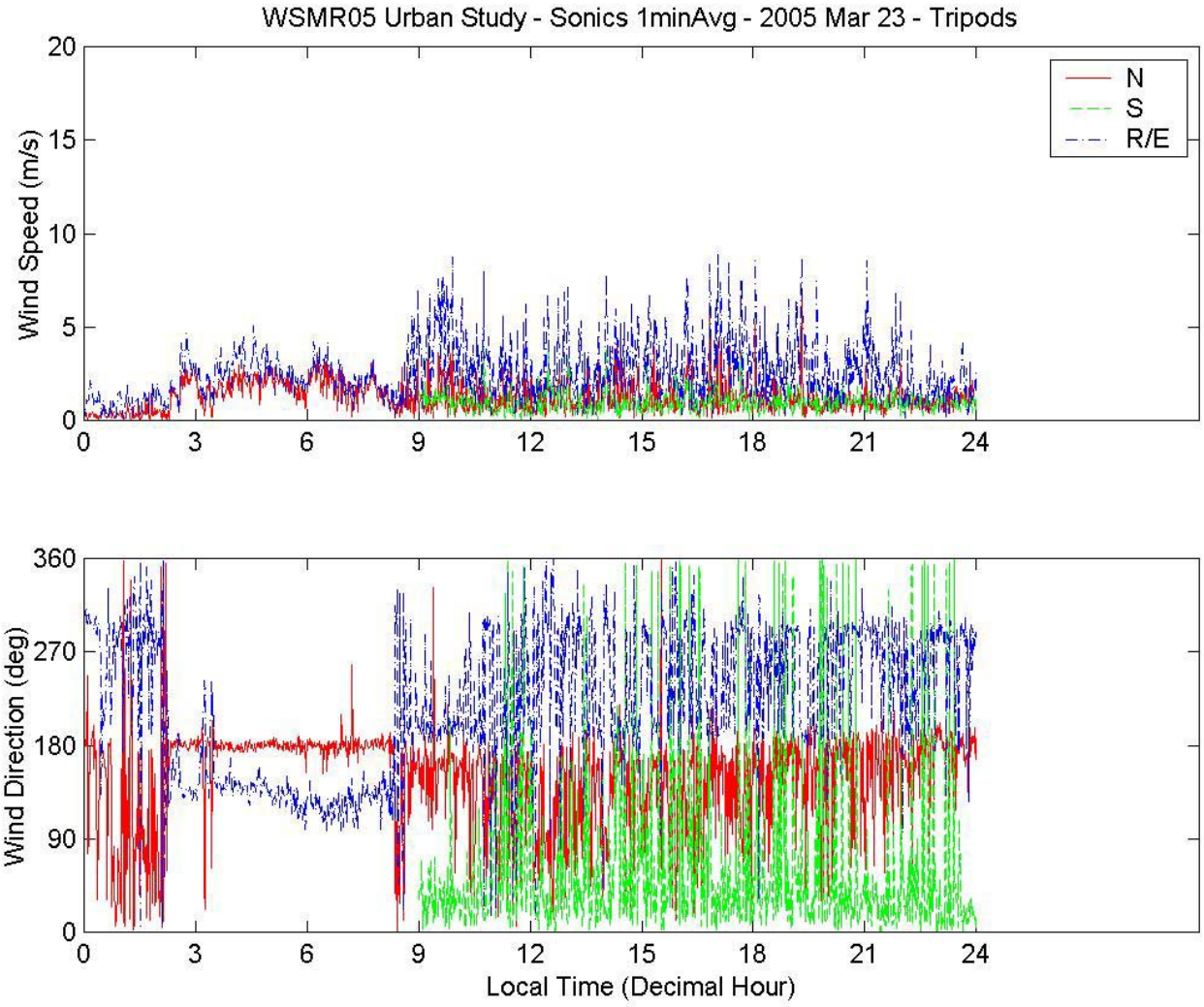
# 4. 2005 March: Phase II Preliminary Results.

## "THE CAVITY"

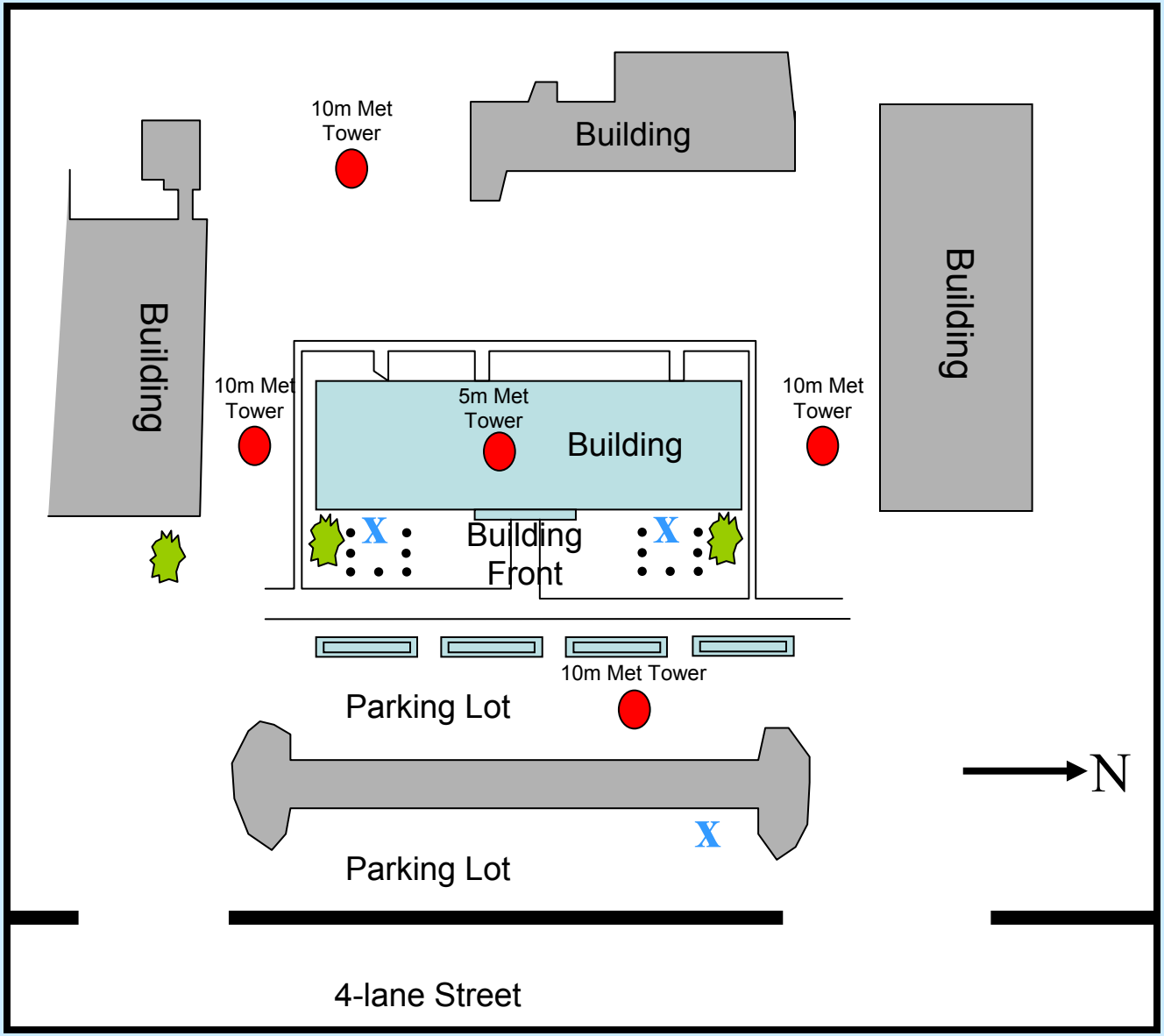


# 4. 2005 March: Phase II Preliminary Results.

## "THE RE-ATTACHMENT and LEESIDE EDDIES"



# Phase II: Field Site Layout
# (Not drawn to scale)



# 4. 2005 March: Phase I Preliminary Results.

➲**Urban Simulations - usually use Neutral temperature profiles.**

➲ **Lessons learned:**

| **Cases** | **Temperature profile** |
|---|---|
| Day(Small bldg complex) | Use Neutral and Unstable. |
| Night(Small bldg complex) | Use Stable, Neutral and Unstable. |

Implied Lesson Learned:

| | |
|---|---|
| Day(City-large bldg complexes) | Use Neutral and Unstable. |
| Night(City-large bldg complexes) | Use Neutral and Unstable. |

➲ **Military Application:**

CBN toxic corridors – maximizes effects with traditional Neutral profiles.

**Optical propagation – minimizes effects with Neutral profiles.**

**– maximizes effects with Unstable profiles.**

**Need to include Unstable (and Stable) cases in Urban simulations.**

# 4. 2005 March: Phase II Preliminary Results.

## DYNAMIC Urban Atmospheric Effects

- One Building does Disturb Airflow.
  - Accelerated flow over building.
  - Velocity Deficit Downwind.
  - Flow Reversal in the Lee.
  - Channeling Flow.
  - Corner Vortices and Re-attachment Zone detected.
- Vortex generation/degeneration – based on
  Wind Direction, Wind Speed Range and Stability factors.

**Implication for modeling/simulations….**

**Diffusion about Buildings**

**Corner vortices lead to elevated concentrations on building leeside.**

**Aid in placement of bio-detection sensors inside MOUT.**

# Questions?

Phase II

2005 March